

## METHOD AND APPARATUS FOR MANUFACTURING PNEUMATIC TIRE

### BACKGROUND OF THE INVENTION

The present invention relates to a method and an apparatus for manufacturing a pneumatic tire in which a lug groove is formed on a tire tread surface.

On a tire tread surface of a pneumatic tire, there are formed a plurality of lug grooves directed about perpendicularly to circumferential direction of the tire and arranged in a row along the circumference of the tire in order to increase friction to the ground and therefore traction force. Especially, a tire for a large-sized construction vehicle has large lug grooves.

Such lug grooves on the tire tread surface are formed when a green tire is vulcanization-molded in a mold. The mold has lug groove ribs for forming the lug grooves, and the lug groove ribs cut into the tread rubber to form the lug grooves when the green tire is vulcanization-molded.

In case of a tire formed with deep lug grooves such as a tire for construction vehicle, volume of rubber removed by the lug groove rib cutting into the tread rubber is large. Therefore, a pressing force by the lug groove ribs arranged circumferentially at regular intervals acts on a belt member inside of the tread rubber largely, so that such inconveniences that a large waving of the belt member (belt wave) is caused, belt gauge (thickness of the belt member) becomes uneven or a joint portion is broken away, are apt to occur.

Especially, regarding a tire for a construction vehicle which uses a belt of low expansion rate as a tire component member, in order to prevent the lug groove rib from biting at the green tire when the mold is closed and in order to remove the lug groove rib from the produced lug groove smoothly when the mold is opened, a split mold type vulcanization-molding machine having split mold parts which are obtained by splitting the mold in a circumferential direction of the tire and movable in radial directions must be used.

However, the above-mentioned vulcanization-molding machine has a complicated construction and requires a large installation space and a high equipment cost. Especially, in case of the tire for large-sized construction vehicle, much more installation space and equipment cost are required.

#### SUMMARY OF THE INVENTION

The present invention has been accomplished in view of the foregoing and an object of the invention is to provide a method and an apparatus of simple construction for manufacturing a pneumatic tire in which the belt wave and unevenness of the belt gauge are restrained to a minimum, joining of the joint portion can be ensured, the installation space is smallest within the limit of necessity, and the equipment cost is low.

In order to achieve the above object, the present invention provides a method for manufacturing a pneumatic tire in which a green tire having tire components assembled is charged in a mold for vulcanization-molding and lug grooves are formed on a tire surface. The method includes previously forming curved grooves at positions on a surface of the green tire corresponding to the lug grooves extending in substantially the same direction as the lug grooves.

Since carved grooves are formed previously, before the green tire is vulcanization-molded, at portions on a surface of the green tire where lug grooves are to be formed extending in substantially the same direction as the lug grooves, volume of rubber displaced by lug groove ribs of the mold of the vulcanization-molding machine cutting into the tread surface is small and pressing force caused by the lug groove ribs is small, so that unevenness of the belt wave and the belt gauge caused by the pressing force acting on a belt member inside of the tread rubber can be restrained small, and joining of joint portions can be ensured.

In the above-mentioned pneumatic tire manufacturing method, the carved groove may be carved in a shape opened from

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a tread center side to a tread end. Carving work can be carried out easily.

The carved groove may be carved in a shape opened from a neighborhood of a closed end point of the lug groove to the tread end. The closed end point of the lug groove means a tip end point of the lug groove on the tread center side where the lug groove rib of the mold touches the green tire firstly when the mold is closed. Since the carved groove is carved in the above-mentioned shape, the lug groove rib enters the carved groove smoothly on molding and a predetermined lug groove can be formed accurately.

The closed end point of the lug groove may be distant from a tread center by a distance larger than 0.1 times of a tread width. Since the carved groove directed about perpendicularly to circumferential direction of the tire is carved on a surface of the green tire in a shape opened from the closed end point distant from a tread center by a distance larger than 0.1 times of a tread width to a tread center, the carving work can be carried out more easily.

A main part of the lug groove may be inclined with regard to axis of the tire at an angle of 5 degrees and more and 45 degrees and less. Since the carved groove extending in the same direction as the lug groove is also inclined with regard to axis of the tire at an angle of 5 degrees and more and 45 degrees and less, the lug groove rib of the mold enters the carved groove easily on molding and a predetermined lug groove can be formed accurately.

The carved groove may be carved in a shape opened from one tread end to another tread end. A lug groove extending continuously from one tread end to another tread end can be formed easily and a tire exhibiting excellent traction force can be manufactured.

516 C17 The carved groove may be carved in a shape opened from a tread center side to a tread end gradually widening. The lug groove rib enters the carved groove easily when the mold is closed and a full mold composed of upper and lower split half

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C7 parts can be adopted in the vulcanization-molding machine easily. Further, volume of space at a part of the carved groove not overlapping with a lug groove formed by the lug groove rib can be made so small that the space can be filled with a rubber flowing into it easily on vulcanization-molding. Thus, wrinkles caused by the space not filled with the rubber can be restrained effectively to improve appearance of the tire.

The carved groove of the gradually widening shape may be formed by carrying out the carving twice using a cutter. The gradually widening carved groove can be formed easily without necessitating a special cutter.

The carved groove may be carved along direction of the lug groove and along direction of axis of the tire from or toward a neighborhood of the closed end point of the lug groove. The carved groove can be carved along direction of the lug groove from a neighborhood of the closed end point or toward the neighborhood of the closed end point, so that an optimum carving direction can be selected in accordance with condition of the equipment.

Volume of the carved groove may be 0.4 - 1.2 times of volume of the lug groove. If volume of the carved groove exceeds 0.4 times of volume of the lug groove, it is possible to lessen influence of the vulcanization-molding on the belt layer to restrain the belt wave small and ensure joining of the joint portion. If volume of the carved groove is less than 1.2 times of volume of the lug groove, it is possible to restrain generation of bear and avoid poor vulcanization.

Volume of the carved groove may be 0.7 - 1.0 times of volume of the lug groove. Generation of the belt wave and the bear can be prevented about surely.

Depth of the carved groove may be 0.5 - 0.9 times of depth of the lug groove. If depth of the carved groove is less than 0.5 times of depth of the lug groove, volume of rubber displaced by the lug groove rib of the mold on vulcanization-molding is too much, and if depth of the carved groove is larger than 0.9 times of depth of the lug groove, gap between the carved groove

and the lug groove rib becomes large, to cause such inconveniences that the bear is liable to be generated to bring about poor vulcanization.

The tire components may include a belt member having a relatively low expansion rate. A tire having a belt member of relatively low expansion rate such as a belt member having an embedded cord directed substantially in the circumferential direction, can be manufactured using a full-mold vulcanization-molding machine applied with the present method.

Expansion rate of the belt member may be 3% and less. The present manufacturing method can be applied to a tire with a belt member having an expansion rate of 3% and less.

A full-mold vulcanization-molding machine having an upper mold and a lower mold may be used as a mold for vulcanizing and molding the green tire. Since the carved grooves extending about in direction of the lug groove are carved on surface of the green tire previously, a full-mold vulcanization-molding machine having upper and lower half split molds can be used. The vulcanization-molding machine is simple in construction, its installation space is small and its equipment cost is low. Especially, in case of a tire for a large-sized construction vehicle, the installation space and the equipment cost can be reduced much more.

The lug groove ribs on the upper and lower molds may be fitted in the carved groove of the green tire when the green tire is charged in the full-mold vulcanization-molding machine. Since the lug groove ribs of the upper and lower molds are fitted in the carved groove of the green tire, the lug groove rib cuts into the tread rubber easily and volume of displaced rubber becomes small. Therefore, pressing force by the lug groove rib is small, the belt wave and unevenness of the belt gauge caused by the pressing force acting on the belt member inside of the tread rubber can be restrained small as possible, joining of the joint portion is ensured, and generation of wrinkles can be prevented.

According to another aspect of the invention, there is

provided a method for manufacturing a pneumatic tire, comprising: a step of manufacturing a green tire in which ribbon-like or sheet-like extruded rubber is piled up on a ply and a belt member assembled on a drum to form a tread; a step of forming a carved groove on a tread surface of the green tire in direction of a lug groove; and a step of charging the green tire formed with the carved groove in a vulcanization-molding machine to carry out vulcanization-molding.

In this method, the carved groove is formed on the tread surface of the green tire in direction of a lug groove after the step of manufacturing the green tire, then the green tire is charged in the vulcanization-molding machine to carry out vulcanization-molding. Therefore, pressing force by the lug groove rib is small, the belt wave and unevenness of the belt gauge caused by the pressing force acting on the belt member inside of the tread rubber can be restrained small as possible, and joining of the joint portion is ensured.

According to a further aspect of the invention, there is provided an apparatus for manufacturing a pneumatic tire which is a full-mold vulcanization-molding machine having an upper and a lower mold each provided with lug groove ribs, and guide means provided on the molds for letting the lug groove ribs fit to carved grooves formed on a green tire when the green tire is charged in the full-mold vulcanization-molding machine.

In this apparatus, the lug groove ribs of the upper and lower molds can be fitted in the carved groove of the green tire accurately owing to the guide means, so that volume of rubber displaced by the lug groove ribs cutting into the tread rubber is small. Therefore, pressing force by the lug groove rib is small, the belt wave and unevenness of the belt gauge caused by the pressing force acting on the belt member inside of the tread rubber can be restrained small as possible, and joining of the joint portion is ensured.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram for explaining steps to form a carved

groove on a green tire;

Fig. 2 is a view showing a part of a tread surface carved with one cutter;

Fig. 3 is a view showing a part of a tread surface carved with two cutters;

Fig. 4 is a partly broken perspective view showing a green tire formed with carved grooves;

o Figs. 5<sup>A</sup>(1) to 5<sup>C</sup>(3) are schematic views showing a vulcanization-molding machine;

Fig. 6 is a view showing a part of a tread surface formed with a lug groove;

Fig. 7 is a sectional view showing inner structure of a portion near a lug groove of an ORR tire;

Fig. 8 is a partly broken perspective view showing a structure of the ORR tire;

Fig. 9 is a partial side view of an upper mold and a lower mold of a vulcanization-molding machine joined together according to another embodiment;

Fig. 10 is a sectional view taken along the line X - X of Fig. 9;

Fig. 11 is a plan view viewed in the direction of the arrow XI of Fig. 9; and

Fig. 12 is a side view similar to Fig. 9 showing a modification.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Sub Hereinafter, an embodiment of the present invention will be described with reference to Figs. 1 to 8. The embodiment relates to manufacturing of an ORR tire (off the use radial tire) for a large-sized construction vehicle.

As shown in Fig. 8, the ORR tire 1 comprises a carcass 2 consisting of a radial cord layer as a foundation, a belt 3 wound round the carcass 2, and a tread 4 wound round the belt 3 covering a crown section and a shoulder section.

The belt 3 is a rubber member having steel cords 3' embedded directed in substantially circumferential direction.

Both ends of the belt 3 are joined to each other. Expansion rate (rate of change of circumferential length) of the belt on vulcanization is relatively low, 3% and less, because the steel cord 3' is directed in substantially circumferential direction.

In Fig. 1, G denotes a green tire which is a state of the ORR tire 1 before vulcanization. The green tire G is supported so as to rotate and one side of a tread 4 thereof is carved using two cutters Ca, Cb.

The cutters Ca, Cb have edges charged with electric current to be superheated and carve the tread rubber melting it. Shapes of the edges of the cutters Ca, Cb are somewhat different from each other and cutting angles are also different from each other. The cutters Ca, Cb carve the same place partly overlapping each other for forming one carved groove 8.

W 327 In Figs. 2 and 3 showing a part of surface of the tread 4, TC and TE denote a tread center and a tread end, respectively. And Fig. 2 shows a carved groove 8a formed on the surface of the tread 4 using the cutter Ca. The carved groove 8a is formed so as to elongate from a position distant from the tread center TC by a distance d (neighborhood of a closed end point P of a lug groove 9 (see Fig. 6)) to the tread end TE substantially in direction of the lug groove (direction inclined about 30 degrees to an axis of the tire).

Fig. 3 shows the carved groove 8a and a carved groove 8b formed overlapping the groove 8a. The carved groove 8b extends from a midway of the carved groove 8a to the tread end TE substantially in parallel with axis of the tire so that a triangular carved groove 8 is formed by both carved grooves 8a, 8b.

Alternatively, the carved groove 8a may be formed after the carved groove 8b is formed. The grooves 8a, 8b can be carved starting from the neighborhood of the closed end portion P of the lug groove 9 or toward the closed end point P. A most suitable covering direction can be selected in accordance with conditions of the equipment.

Anyway, the carved groove 8 is formed in a triangle



gradually widening from the side of the tread center TC toward the tread end TE and opening continuously from a circumferential surface of the tread 4 to a side surface of the tread end.

Such carved grooves 8 are formed using the cutters Ca, Cb on the tread 4 of the green tire G in a circumferential direction at regular intervals. Thus, the carved groove opened gradually widening can be formed without using a special cutter. After the carved grooves 8 have been formed on one side of the tread 4, similar carved grooves 8 are formed on another side of the tread 4.

Fig. 4 shows a green tire G formed with the carved grooves 8 in the above-mentioned manner. Referring to Fig. 3, the carved grooves 8 are formed from a position apart from the tread center TC by a distance d to the tread end TE, and the distance d is set at a value larger than 0.1 times of the tread width D.

The green tire G is charged in a full-mold vulcanization-molding machine 10 for vulcanization-molding. The full-mold vulcanization-molding machine 1 has a half-spritt mold consisting of an upper mold 11 and a lower mold 12 as shown in Fig.5 schematically.

On inner surfaces of the upper and lower molds 11, 12 are arranged respective lug groove ribs annularly. The lower mold 12 is fixed with the mold face turned upward, and above the lower mold 12 is supported the upper mold 11 movably upward and downward with the mold face turned downward. The upper mold 11 is supported so as to freely rotate about a vertical axis.

The upper and lower molds 11, 12 have respective slide guides 13, 14 projecting opposite to each other. The slide guides 13, 14 have respective slide faces coming into sliding contact with each other. The slide face is formed by a curved or straight surface inclined substantially in parallel with the lug groove.

The upper mold 11 and the lower mold 12 are joined with each other putting the green tire G between them for vulcanization-molding. At that time, as shown in Fig. 5(A), the



is shown by the solid line. The lug groove 9 overlaps the triangular carved groove 8.

The carved groove 8 is carved starting from the neighborhood of the closed end point P which is a tip end near the tread center TC of the lug groove 9 to be formed by vulcanization molding. The lug groove rib of the mold touches the green tire firstly at the closed end point P of the lug groove 9 when the mold is closed, and the carved groove 8 is carved in a shape opened from the neighborhood of the closed end point P of the lug groove 9 to the tread end TE, therefore the lug groove ribs enter the carved grooves 8 smoothly when the mold is closed and specific lug grooves can be formed accurately.

The carved groove 8 is formed on a surface of the green tire extending about perpendicularly to the circumferential direction from the neighborhood of the closed end point P distant from the tread center TC by a distance larger than 0.1 times of the tread width to the tread end TE. Therefore, the carving work can be carried out easily.

The direction of the main part of the lug groove 9 is inclined about 30 degrees to the direction of the tire axis, and the direction of the longer carved groove 8a coincides with the direction of the lug groove.

If the inclination angle of the lug groove to the tire axis is 5 degrees and more, and 45 degrees and less, when the upper mold is joined with the lower mold while rotating on vulcanization-molding, the lug groove ribs of the upper and lower molds easily enters the carved grooves of the green tire G while turning, and a specific lug groove 9 can be formed accurately.

The volume of the carved groove 8 is selected so as to be within the limits of 0.4 - 1.2 times of the volume of the lug groove 9 to be formed by vulcanization-molding. If the volume of the carved groove 8 is smaller than 0.4 times of the volume of the lug groove 9, amount of rubber displaced by the lug groove rib of the mold on vulcanization-molding is too much so that pressing force by the lug groove rib is large and the

belt wave by the pressing force acting on the belt 3 inside of the tread 4 is generated greatly.

Therefore, by selecting the volume of the carved groove 8 so as to be 0.4 times and more of the volume of the lug groove 9, the belt wave can be restrained small as far as possible as shown in Fig. 7. Further, also unevenness of the belt gauge can be restrained small as far as possible and joining of the joint portion of the belt 3 is also ensured. As mentioned above, by forming the carved groove 8 starting from the neighborhood of the closed end point P of the lug groove 9, the belt wave can be made small further.

On the one hand, if the volume of the carved groove 8 is larger than 1.2 times of the volume of the lug groove 9, a gap between the carved groove and the lug groove rib is so large that the bear is apt to be generated to cause poor vulcanization.

Particularly, if the volume of the carved groove is 0.7 - 1.0 times of the volume of the lug groove, the amount of rubber displaced by the lug groove rib of the mold on vulcanization-molding is little, the lug groove rib cuts into the tread rubber easily and pressing force by the lug groove rib is small, so that the belt wave and unevenness of the belt gauge by the pressing force acting on the belt member inside of the tread rubber can be restrained to a minimum, joining of the joint portion can be ensured much more and poor vulcanization caused by generation of the bear can be prevented surely.

Since the lug groove rib enters the carved groove 8 fitting it, volume of a part of the carved groove 8 not agreeing with the lug groove 9 is small and the same part is easily filled with rubber flowing into it to prevent generation of wrinkles and maintain a good appearance.

Depth of the carved groove 8 is set to be 0.5 - 0.9 times of depth of the lug groove. If depth of the carved groove 8 is smaller than 0.5 times of depth of the lug groove, amount of rubber displaced by the lug groove rib on vulcanization-molding is too much. If depth of the carved groove 8 is larger

than 0.9 times of depth of the lug groove, a gap between the carved groove and the lug groove rib is so large that the bear is apt to be generated and poor vulcanization is caused similarly to the above case regarding volume. These problems can be solved by selecting depth of the carved groove to 0.5 - 0.9 times of depth of the lug groove.

Thus, a large-sized ORR tire 1 for a construction vehicle shown in Fig. 8 is manufactured. On this tire 1, a plurality of lug grooves 9 each extending from a position of the tread near the tread center TC to the tread end TE are formed at regular intervals.

As mentioned above, by forming the triangular carved groove 8 on the green tire G previously, the green tire G can be vulcanization-molded using the full-mold vulcanizing-molding machine 10. Therefore, compared with a customary vulcanization-molding machine with split molds, construction of the vulcanization-molding machine itself is simple, the installation space is small and the equipment cost can be reduced greatly.

In the full-mold vulcanization-molding machine 10 shown in Fig. 5, the slide guides 13, 14 of the upper and lower molds 11, 12 have somewhat curved slide face. Figs. 9 to 11 show another example having straight guide faces.

In the full-mold vulcanization-molding machine 30 of Figs. 9 to 11, an upper mold 31 moves up and down relatively to a lower mold 32 while rotating about a vertical axis for opening and closing. The upper mold 31 has an opening end edge projecting downward which is enlarged radially to form an engaging edge section 31a. The engaging edge section 31a engages with an opening end of the lower mold 32 projecting upward covering it from the outside so that the upper and lower molds 31, 32 are aligned and joined with each other.

On a predetermined place of an outer circumferential surface of the upper mold 31 is bolted an upper mold slide guide 33 which is shaped in a triangle with rounded corners. The upper mold slide guide 33 has a taper section of angle of about 25

degrees directed downward and an inclined side forming a slide face 33a which is inclined about 25 degrees to a vertical central axis of the mold or the tire axis.

On the other hand, on an outer circumferential surface of the lower mold 32 and at a position near the upper end thereof is fixed a lower slide guide 34 projecting upward. The lower mold slide guide 34 has a lower end portion bolted to the lower mold 32. The lower mold slide guide 34 has a shape of right-angled triangle similar to that of the upper mold slide guide 33 and is more than twice as large as the upper mold slide guide 33. The lower mold slide guide 34 has a shortest side bolted and a taper section of angle of about 25 degrees projecting upward.

The inclined side of the lower mold slide guide 34 forms a slide face 34a inclined about 25 degrees to the tire axis. The slide face 34a is opposite to the slide face 33a of the upper mold slide guide 33 for sliding contact. The above inclination angle of about 25 degrees of the slide faces 33a, 34a is equal to the angle of the lug groove ribs 36, 37 (Fig. 10) formed on inner surfaces of the upper and lower molds 31, 32.

The lower mold 32 is provided with a stopper 35 side by side with the lower mold slide guide 34. The stopper 35 is bolted at the lower end portion and projected upward similarly to the lower mold slide guide 34. The stopper is contacted with the left end of the lower side of the lower mold slide guide 34 and has a side face on the side of the lower mold slide guide 34 forming a vertical face 35a. Therefore, the inclined slide face 34a of the lower mold slide guide 34 and the vertical surface of the stopper 35 form a wedge-shaped recess opened upward.

When the upper mold 31 having the same center axis as that of the lower mold 32 descends with a predetermined relative rotational angle on vulcanization-molding, center alignment of the molds 31, 32 are carried out in such a manner that the engaging edge section 31a of the upper mold 31 covers the upper end opening edge of the lower mold 32 from the outside. At the same time, the upper mold 31 is rotated while descending as the

slide faces 33a, 34a of the upper and lower mold slide guides 33, 34 slide along each other, and finally the upper mold 31 is joined with the lower mold 31.

When the upper mold 31 has been joined with the lower mold 32, the upper mold slide guide 33 is fitted into the wedge-shaped recess between the lower mold slide guide 34 and the stopper 35 to rotationally position the upper mold 31 relatively to the lower mold 32.

Since the upper mold 31 descend with rotation depending on the inclination angle of the slide faces 33a, 34a, the lug groove ribs 36, 37 directed in the same direction as the inclination angle of the slide faces 33a, 34a are fitted in the carved grooves 8 of the green tire G smoothly without being obstructed by the tread rubber, so that a specific lug groove can be formed accurately.

Fig. 12 shows another example in which the inclination angle of the slide surface is different from that of the above example. Namely, the slide faces 43a, 44a of the upper and lower mold slide guides 43, 44 are inclined about 40 degrees to the tire axis.

Therefore, in this example, the lug groove ribs on inner faces of the upper and lower molds are also inclined about 40 degrees to the tire axis. When the upper mold 41 descends while rotating because of slide motion of the slide guides 43, 44 and joins with the lower mold 42, in spite of the large inclination angle to the tire axis, the lug groove rib is fitted in the carved groove of the green tire smoothly and a lug groove having a inclination angle of 40 degrees to the tire axis is formed with a high accuracy.

Also in this example, a stopper 45 is attached to the lower mold 42 in contact with the lower mold slide guide 44.